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Low exergy technologies for heating and cooling of buildings

Dr. Markku J. Virtanen
Finnish Development Centre for Building Services Ltd.

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Contents of the presentation

- Background - IEA/Annex 37 in brief
- Highlights of Annex 37 results
- Low exergy technologies

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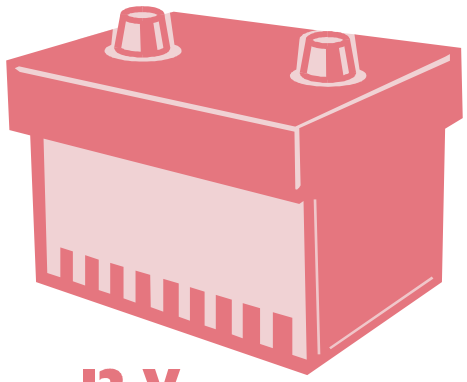
The quality of energy



12 V
2.3 Ah

100 kJ ⟺

1 kg water
at 43°C

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Sources of energy at 20 °C

Source	Quality factor q
Mechanical energy	1.00
Electrical energy	1.00
Nuclear fuel	1.00
Solar radiation	0.95
Fuels	0.90
Thermal at 100 °C	0.21
Thermal at 40 °C	0.06
Thermal at 20 °C	0.00

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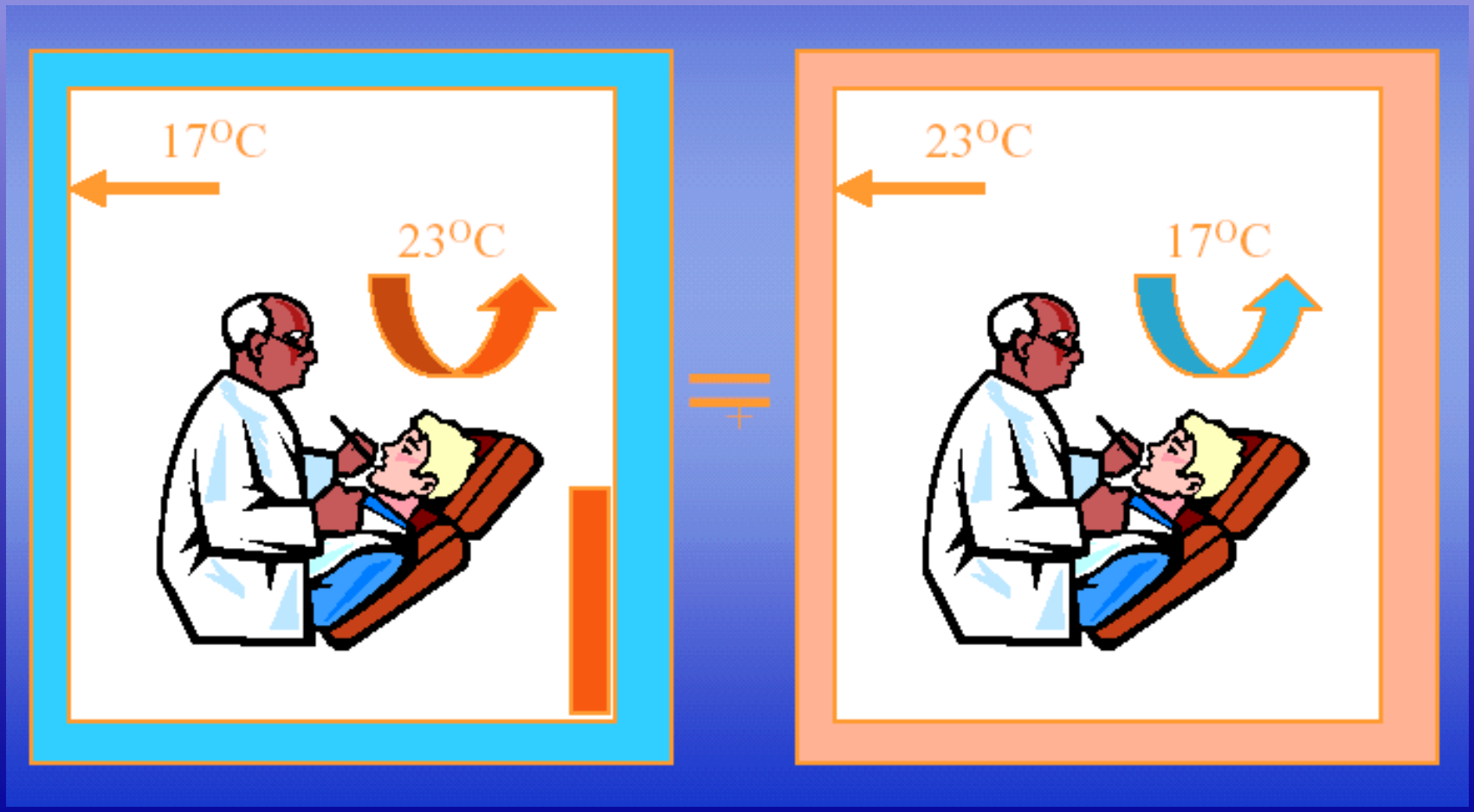
Soft Heat



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Introduction of IEA/Annex 37

Annex 37 "Low Exergy Systems for Heating and Cooling of Building (LowEx)" was carried out in 1999-2003

Focus on practical issues

- exergy analysis tools for pre-design phase
- low exergy concepts and technologies
- case studies and market potentials
- information dissemination

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The LowEx group

- Finland: VTT Building and Transport
- Italy: Ente per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA)
- Japan: Musashi Institute of Technology
- Netherlands: Cauberg-Huygen R.I and NOVEM
- Norway: Norwegian Building Research Institute
- Canada: Natural Resources Canada
- France: Centre Sqientifique et Technique du Batiment (CSTB)
- Sweden: Royal Institute of Technology, Building Technology
- Denmark: Esbensen Consulting Engineers and Technical University of Denmark
- Germany: TU Braunschweig Institut für Gebäude- und Solartechnik *and* D.F. Liedelt "Velta" GmbH
- Poland: Technical University of Silesia

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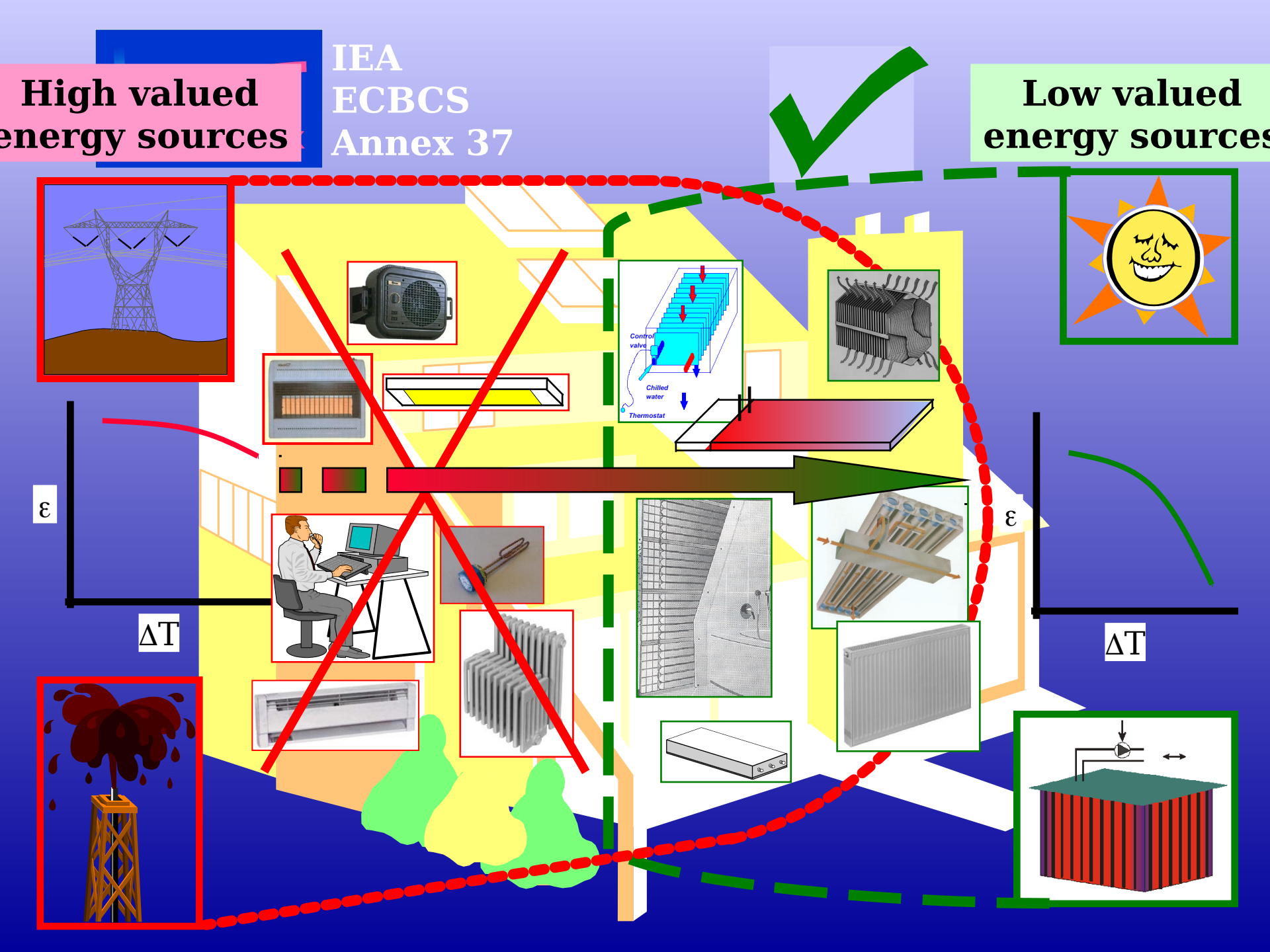
Objectives

The general objective of the Annex 37 was to promote the rational use of energy by means of facilitating and accelerating the use of low valued and environmentally sustainable energy sources for heating and cooling of buildings.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High valued energy sources
Low valued energy sources
Control valve
Chilled water
Thermostat
ε
ΔT
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ΔT

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Research issues

- arguments for use of LowEx systems were not presented in a reliable way
- designers and architects did not know what kind of LowEx solutions exist on the market
- the potential of exergy analysis in comparing the systems was not common knowledge
- the importance of the quality of energy was not recognised in general

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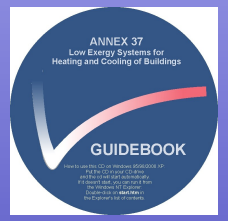
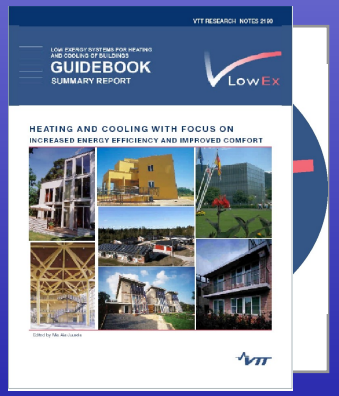
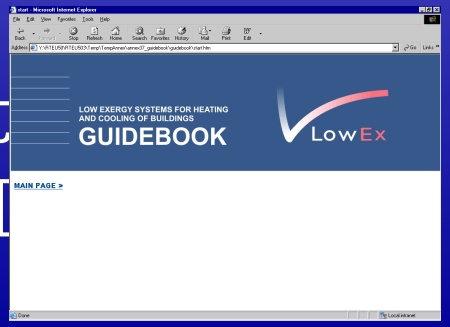
Final products

- A CD-ROM containing the Guidebook in an interactive mode and .pdf format
- A Summary Report to introduce the Guidebook (containing the CD)
- Web-site containing t
information as the CI







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Annex beneficiaries

- Designers of heating and cooling systems in buildings are the main target group
- Engineering firms, consultants and architects
- Real estate owners and builders, building maintenance managers, political decision makers and the public at large

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LowExNet

- An international Society for Low Exergy Systems in Buildings was founded on September 13th, 2003
- Shortname: LowExNet
- Website: www.lowex.net

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Highlights of results…

- Arguments for the use of LowEx systems were collected to be able to present them in a reliable way:
  - an occupants' survey,
  - a litterature study
  - experiences from the cases
  - human body exergy analyses

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…highlights of results…

- All prove, that LowEx systems
  - are well received
  - can provide occupants with comfortable, clean and healthy environment
  - can use a variety of energy sources, which gives flexibility for future
  - allow the renewable sources to be used more efficiently
- Human body exergy analyses are a new way of proving why LowEx systems are comfortable.

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…highlights of results…

- Human body exergy analysis has now started to articulate, why LowEx systems are essential for creating rational and comfortable environment.

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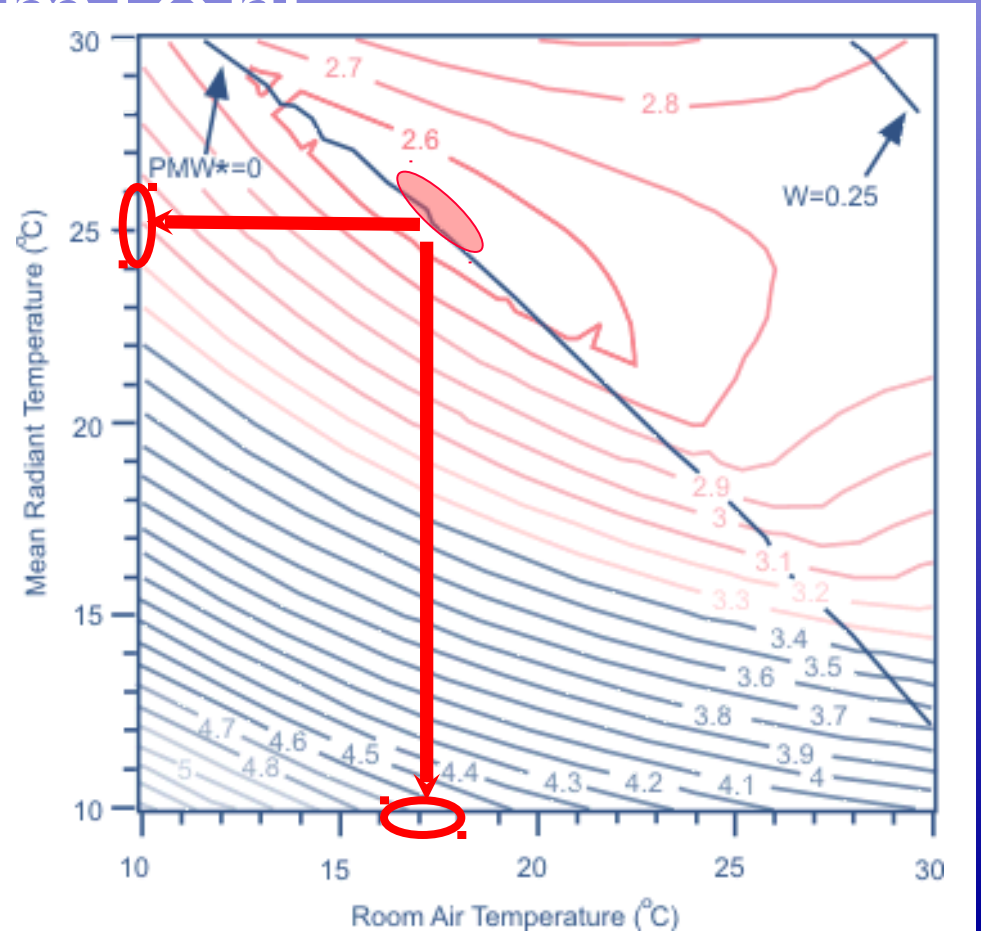
Human body exergy consumption and thermal comfort

- Some experienced scientists and engineers say that what they can see in this picture is consistent with their experiences. Now we are able to calculate the optimal combination.



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…highlights of results

- A LowEx component database was created: sixty data sheets of LowEx components.
- System solutions are presented (e.g. Sensus, Thermonet).
- Design guidelines for design of LowEx systems.
- Case studies provide examples of functional LowEx systems.

Now we have collected the components and some systems, but more system solutions are needed!

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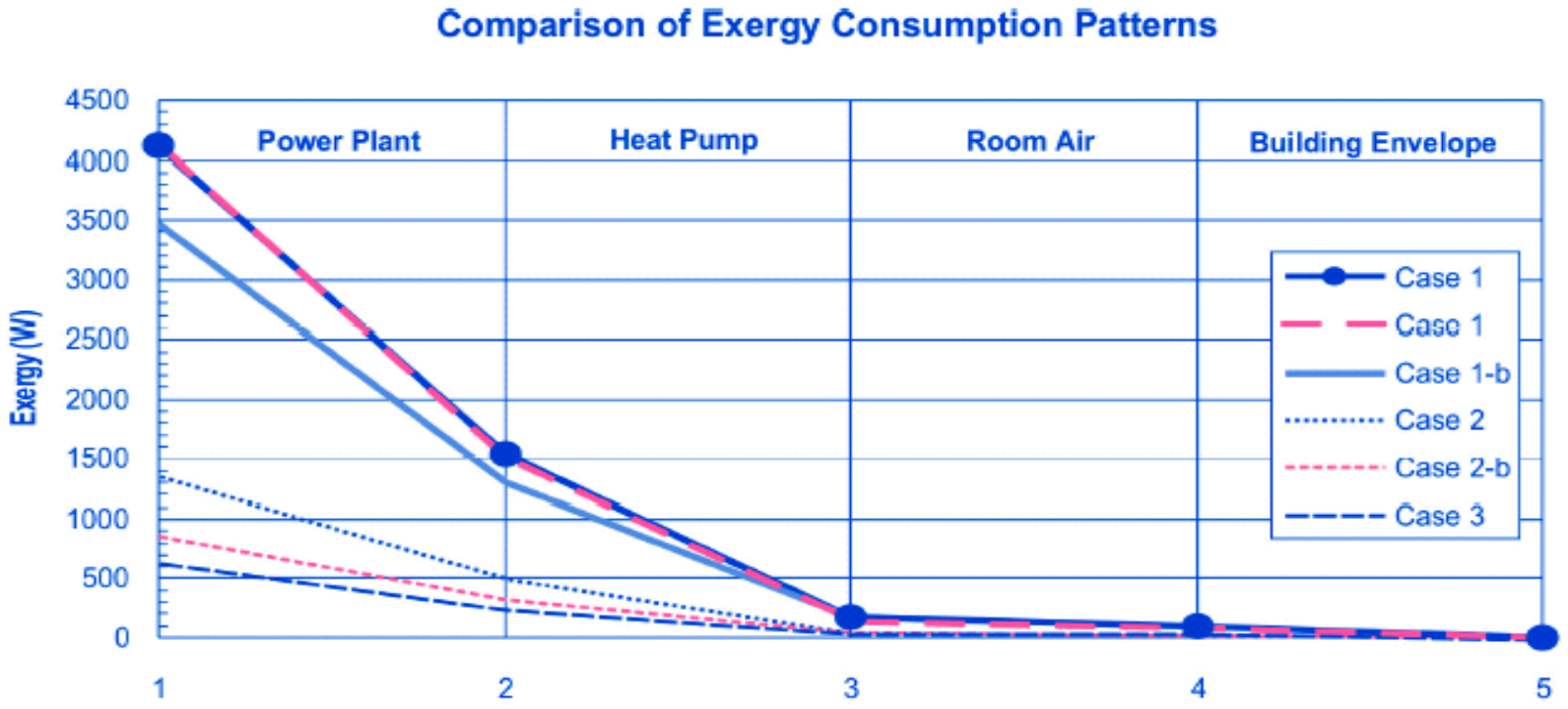
Tool for exergy calculations



Case 1	Base Case - Moderate Thermal Insulation of Building Envelope, Internal Shading Devices
Case 1-b	Improved COP Coefficient
Case 2	Improved Thermal Insulation, External Shading Devices
Case 2-b	Improved Thermal Insulation, External Shading Devices, Improved Electric Lighting
Case 3	Improved Thermal Insulation, COP and Electric Lighting, External Shading Deivices

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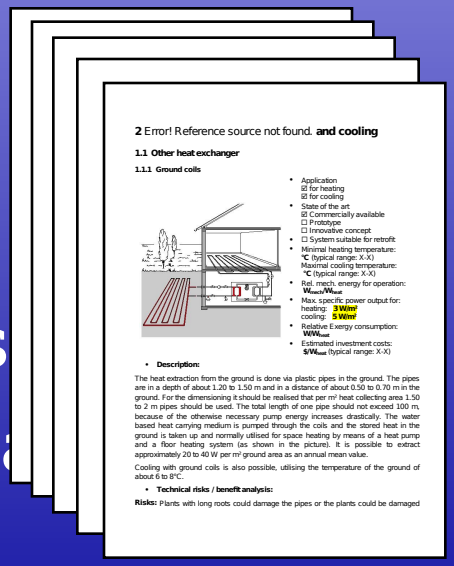
LowEx technologies

- Data sheets of 63 LowEx components
  - Information box and picture
  - Description
  - Technical risks/benefits analys
  - Special advantages, disadvant limitations or side effects



2 Error! Reference source not found. **and cooling**

1.1 **Other heat exchanger**

1.1.1 **Ground coils**

- Application
  ☑ for heating
  ☑ for cooling
- State of the art
  ☑ Commercially available
  ☐ Prototype
  ☐ Innovative concept
- ☐ System suitable for retrofit
- Minimal heating temperature: °C (typical range: X-X)
  Maximal cooling temperature: °C (typical range: X-X)
- Rel. mech. energy for operation: W_{mech}/W_{heat}
- Max. specific power output for: heating: 3 W/m² cooling: 5 W/m²
- Relative Exergy consumption: W/W_{heat}
- Estimated investment costs: $/W$_{heat}$ (typical range: X-X)

- **Description:**

The heat extraction from the ground is done via plastic pipes in the ground. The pipes are in a depth of about 1.20 to 1.50 m and in a distance of about 0.50 to 0.70 m in the ground. For the dimensioning it should be realised that per m² heat collecting area 1.50 to 2 m pipes should be used. The total length of one pipe should not exceed 100 m, because of the otherwise necessary pump energy increases drastically. The water based heat carrying medium is pumped through the coils and the stored heat in the ground is taken up and normally utilised for space heating by means of a heat pump and a floor heating system (as shown in the picture). It is possible to extract approximately 20 to 40 W per m² ground area as an annual mean value.

Cooling with ground coils is also possible, utilising the temperature of the ground of about 6 to 8°C.

- **Technical risks / benefit analysis:**

Risks: Plants with long roots could damage the pipes or the plants could be damaged

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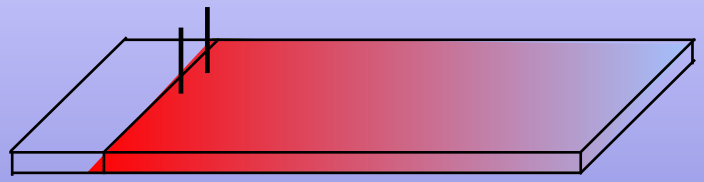
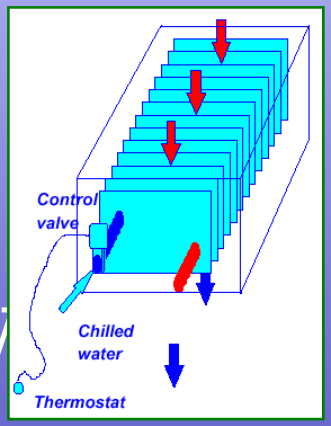
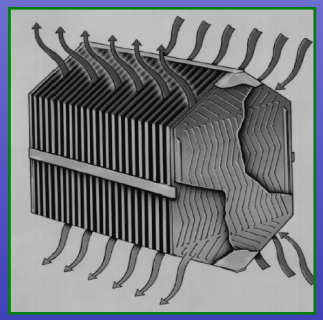
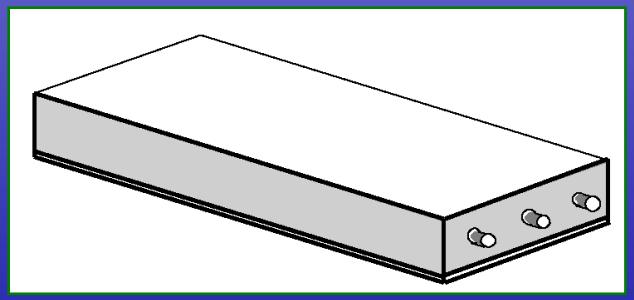


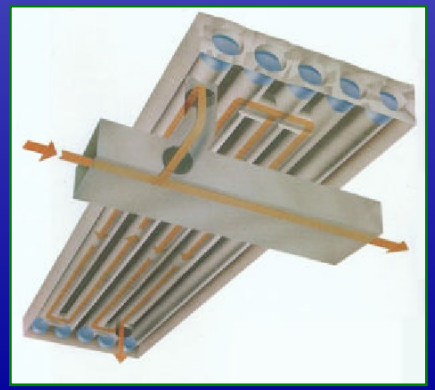
LowEx technologies

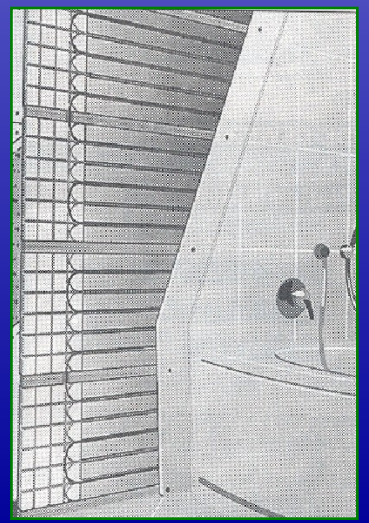
can be compiled to low exergy systems











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LowEx technologies

Table 4. Summary table of the LowEx technologies.

No.	WHAT ?	Suitable for: Residential	Non-residential	New	Retrofit	State of the art: Concept	Experimental	Commerical	Costs (↗ high → medium ↘ low)	Cooling temp. [°C] 0 – 100	Heating temp. [°C] 0 – 100
S	SURFACE HEATING AND COOLING										
S.1	Floor heating										
S.1.1	Embedded coils in slabs		X	X				X		10-15	25-30
S.1.2	Coils in surface layers	X	X	X	X			X		16-20	28-35
S.1.3	Hollow core slabs		X	X	X			X	→	15-18	25-30
S.1.4	Suspended floors	X	X	X				X	→	16-20	30-40
S.1.5	Phase change in floor heating	X	X	X	X		X		↗	-	25-50
S.2	Wall heating and cooling										
S.2.1	Pipes in surface layers (wet/half wet, mounted)	X	X	X	X			X		10-15	25-50

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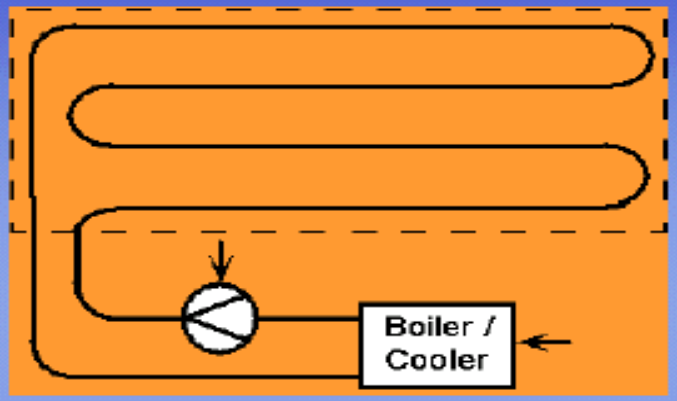
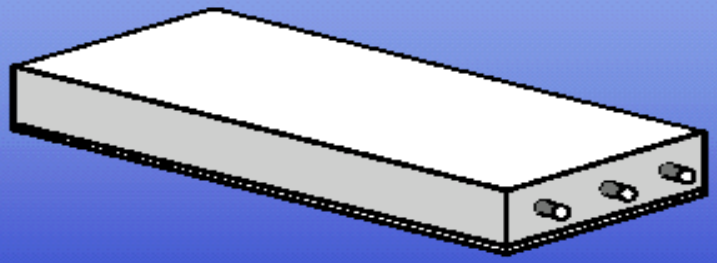
Information box and picture

Living Document





Embedded coils in slabs

Application
☑ for heating
☑ for cooling
State of the art
☑ Commercially available
☐ Prototype
☐ Innovative concept
☐ System suitable for retrofit
Minimal heating temperature:
23 °C (typical range: 25-30)
Maximal cooling temperature:
19 °C (typical range: 10-15)
Rel. mech. energy for operation:
0.0005 Wmech/Wheat
Max. specific power output for:
heating: **70 W/m²**
cooling: **40 W/m²**
Relative Exergy consumption:
0.11 W/Wheat
Estimated investment costs:
3 $/Wheat (typical range: X-X)

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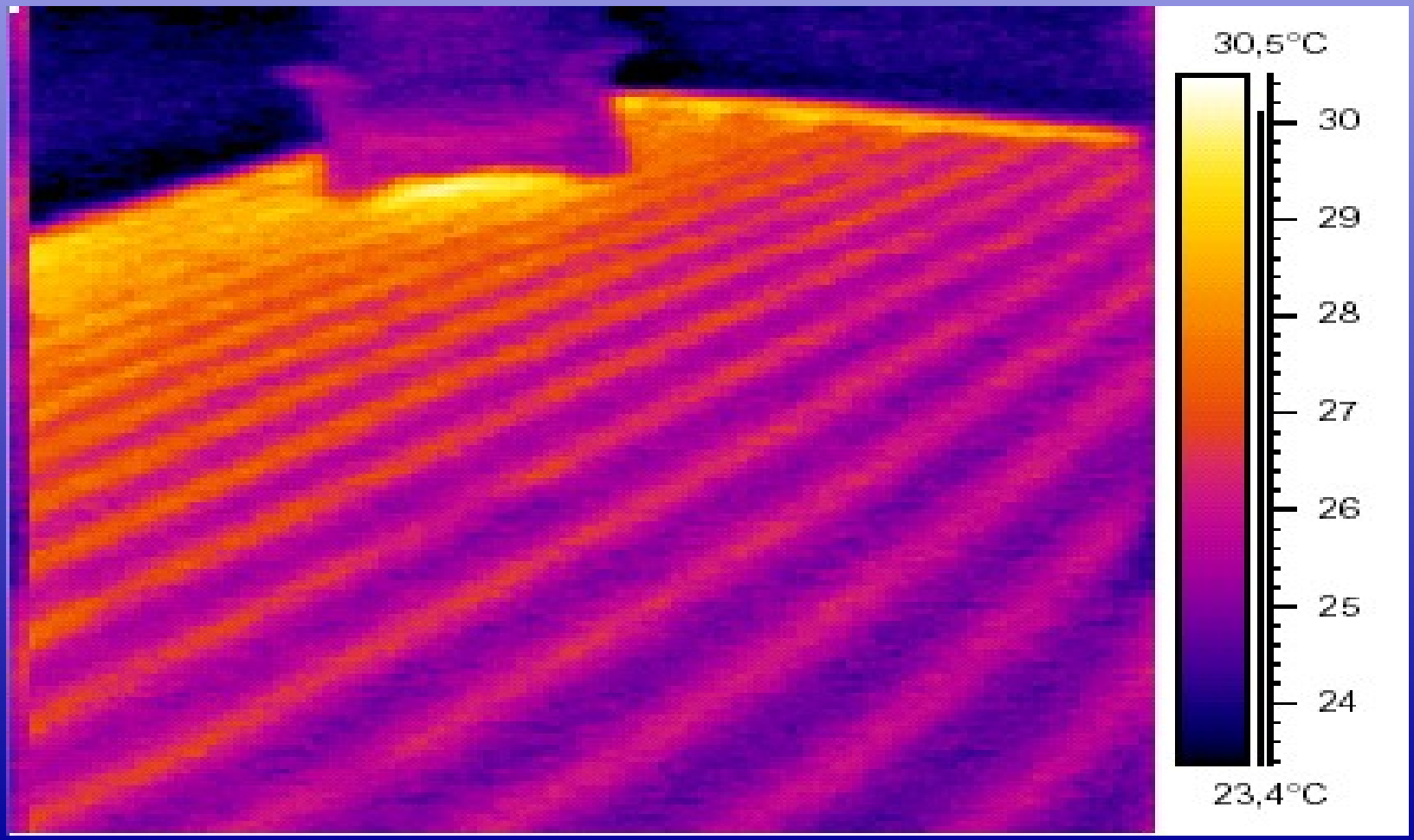
Reverse flow technique



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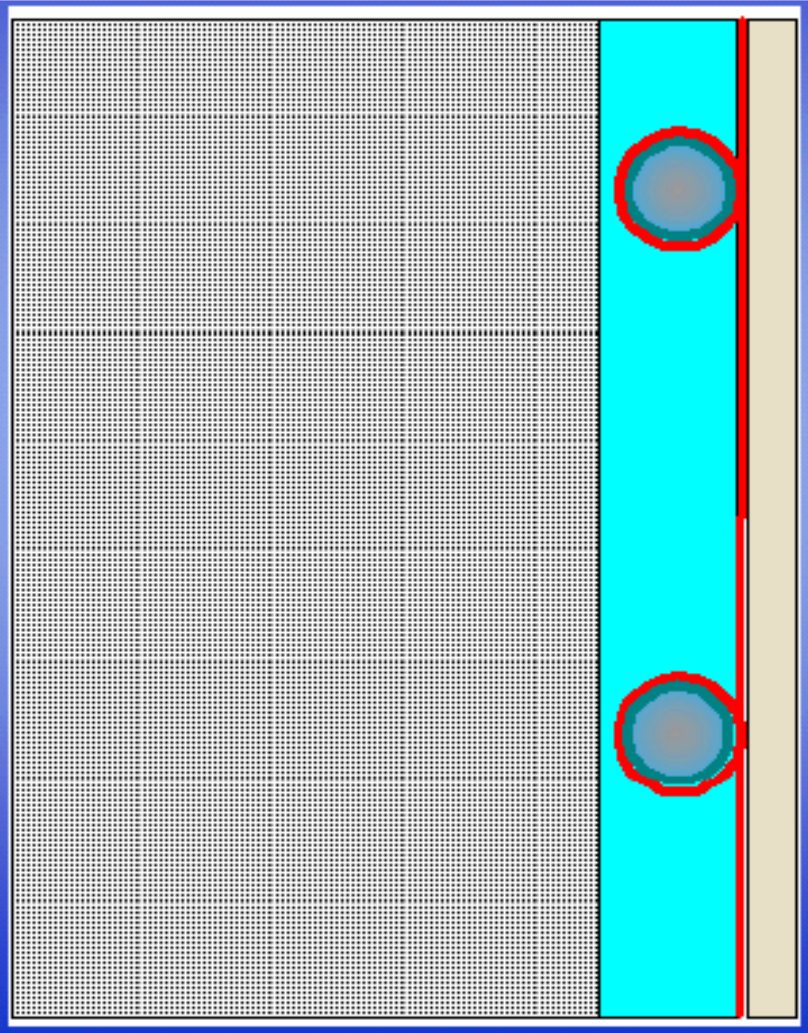
Coils in surface layers



- Application
  - ☑ for heating
  - ☑ for cooling
- State of the art
  - ☑ Commercial available
  - ☐ Prototype
  - ☐ Innovative concept
- Minimal heating temperature:
  28 °C (typical range: 28-35)
  Maximal cooling temperature:
  16 °C (typical range: 16-20)
- Rel. mech. energy for operation:
  W_{mech}/W_{heat}
- Relative Exergy consumption:
  W/W_{heat}
- Estimated investment costs:
  1-2 \$/W_{heat} (typical range: X-X)

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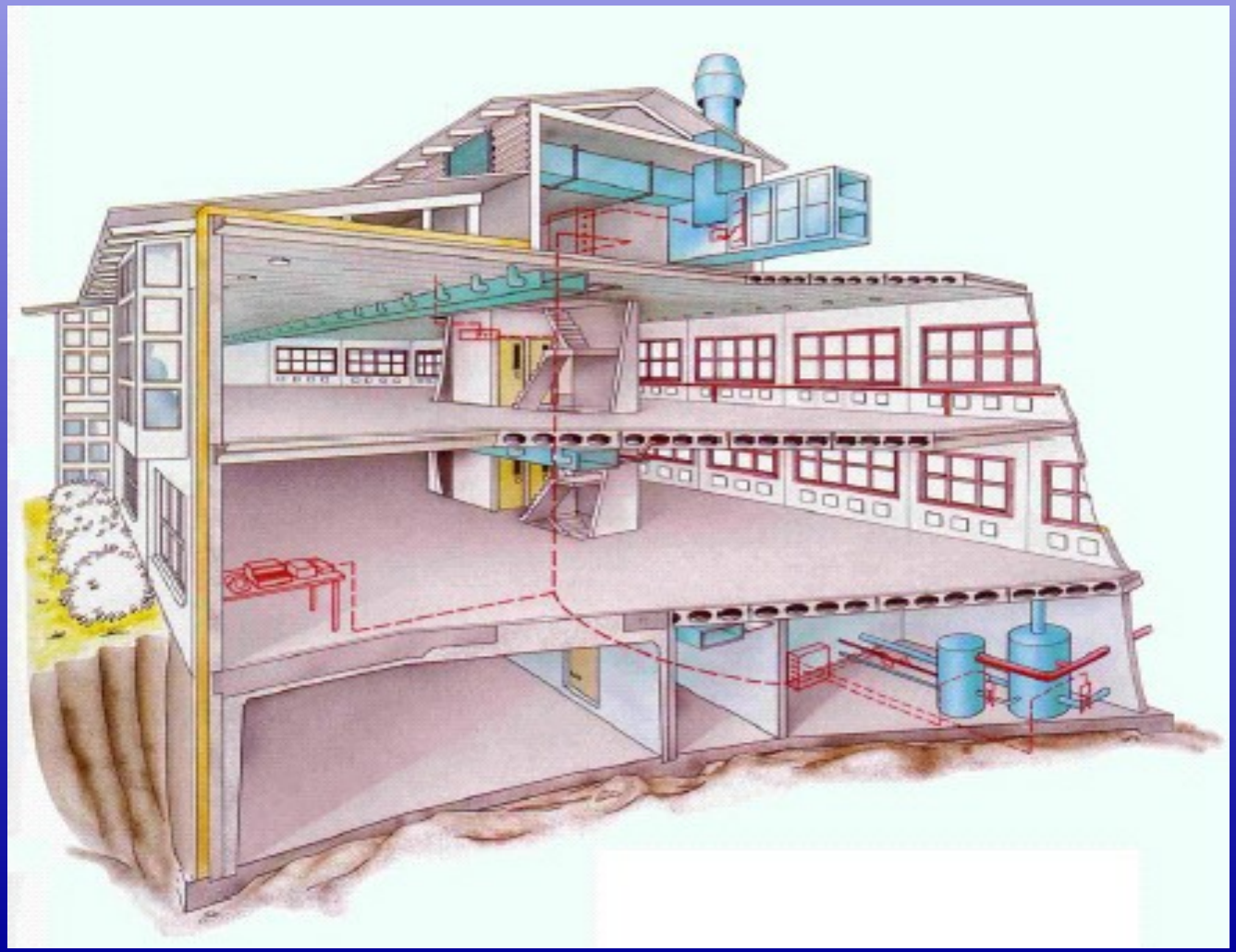
Hollow core slabs



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LowEx technologies

S.3.2 COOLING BEAMS

Application
- [x] for heating
- [x] for cooling

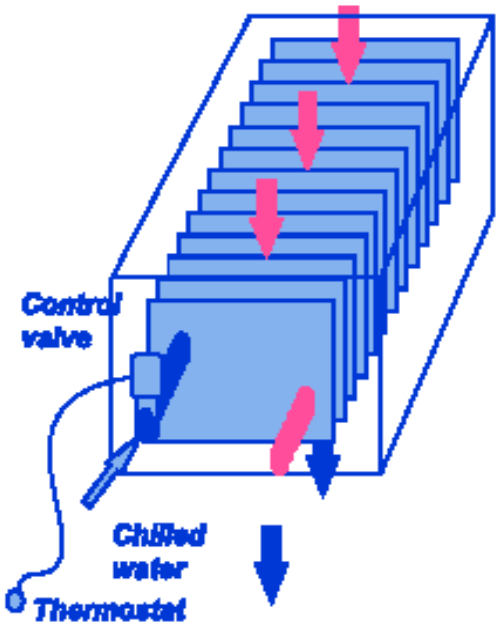
State of the art
- [x] Commercially available
- [ ] Prototype
- [ ] Innovative concept
- [x] System suitable for retrofit

Minimum heating temperature:
40 °C
(typical range: 25-50)

Maximum cooling temperature:
15 °C
(typical range: 10-15)

Max. specific power output for:
heating: 40 W/m²
cooling: 70 W/m²

Estimated investment costs:
0.5 $/$W_{heat}$
(typical range: X-X)



DESCRIPTION

A water-cooled fin-coil element is placed under the ceiling of the room. The air cooled between the fins drops down and is replaced by warmer air.

Function: When cold water passes

get a guarantee that the climate in the building is as intended and that you pay the right price for the products. The main factors that affect the cooling power are the temperature difference between the indoor air (occupied zone) and the mean temperature of the coolant in the beam. The following factors should also be considered:

Temperature stratification in the room: Sometimes the room temperature in the occupied zone and the air temperature around the beam are not the same, i.e. there is a temperature stratification in the room. A stratification (gradient) occurs if, for example, there is sufficiently powerful convective heat sources in the room. A temperature gradient in the room significantly affects the amount of cooling effect gained from the beam. However, a flat chilled beam is affected considerably less due to its low convection. Few chilled beams have any notable radiant exchange with the room surfaces. However, the

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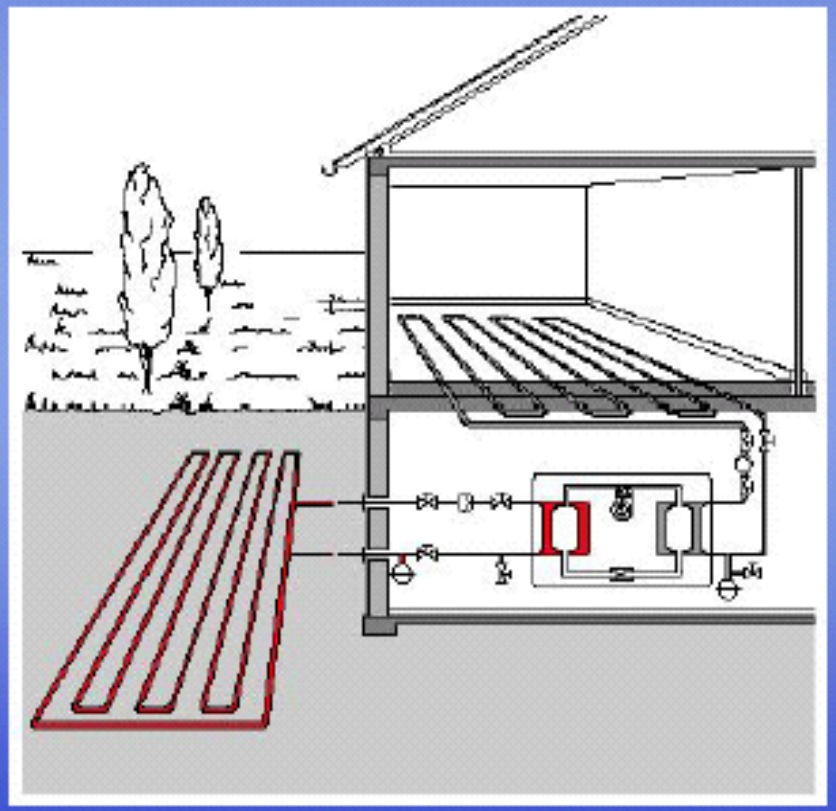
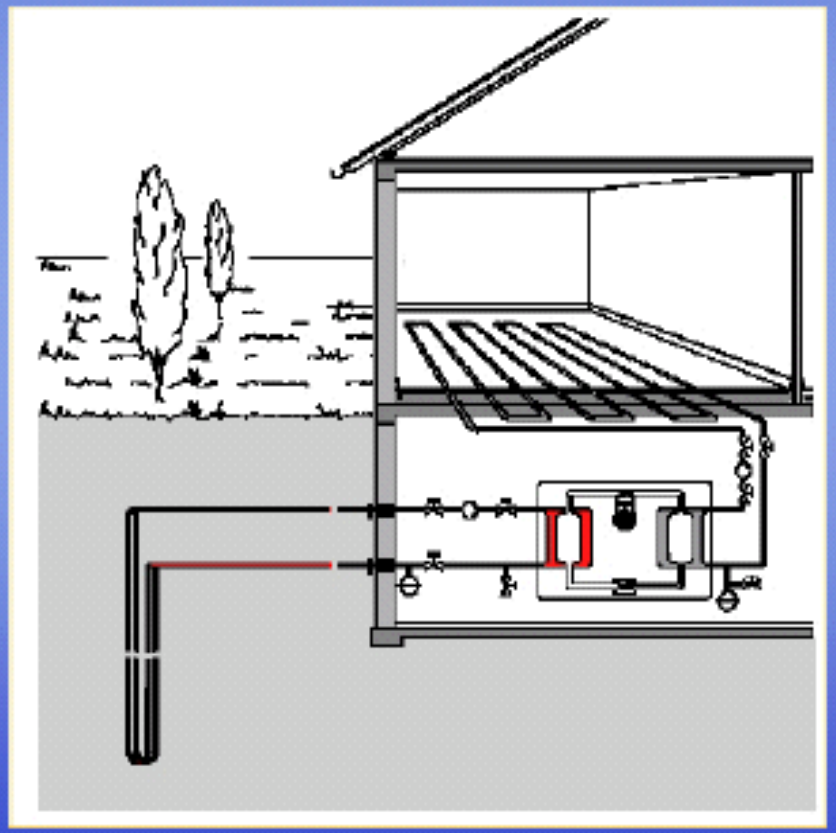
Ground heat exchange





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What is a 'Low Exergy System'?

- A low exergy heating or cooling system is a system that allows the use of low valued energy as the source.
- This means a system where the heat or cold supply temperatures are as close as possible to the desired room temperature.

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Strategies for low exergy heating systems

- Well insulated air tight buildings with mechanical ventilation and heat recovery
- Heat emission over large surfaces
- System design for minimum temperature levels
- Good comfort
- Good regulation and control

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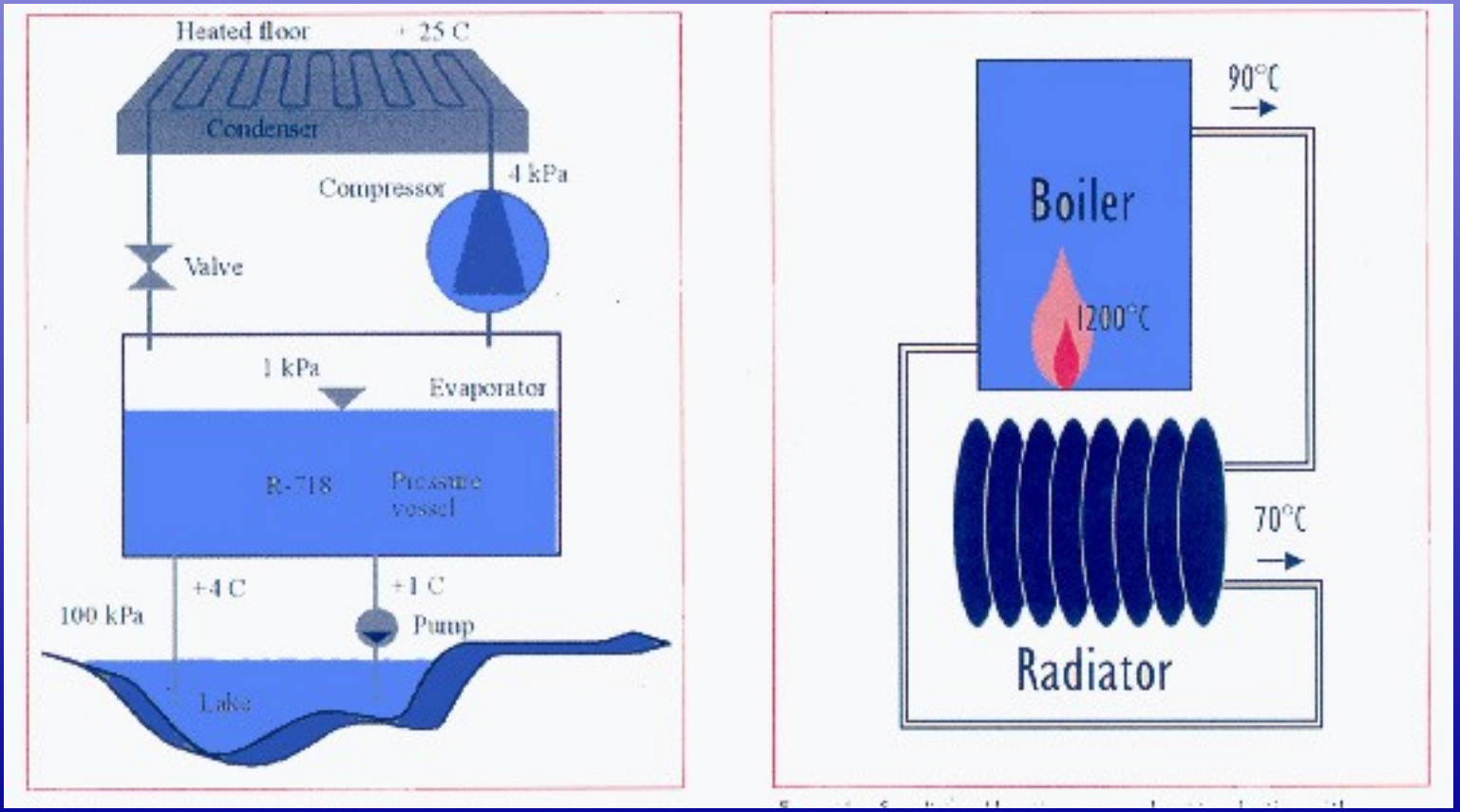
LowEx

HighEx



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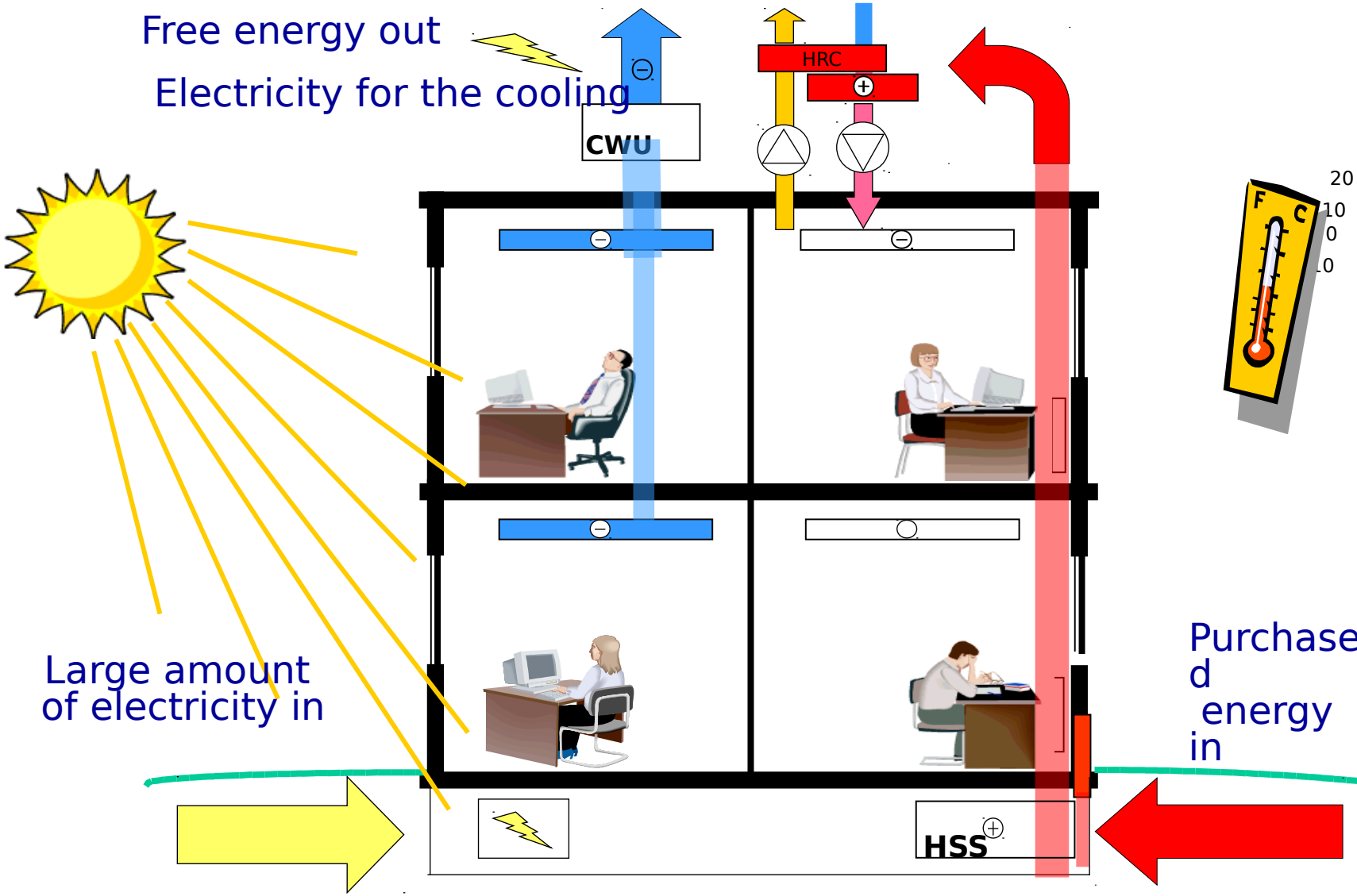
Traditional system



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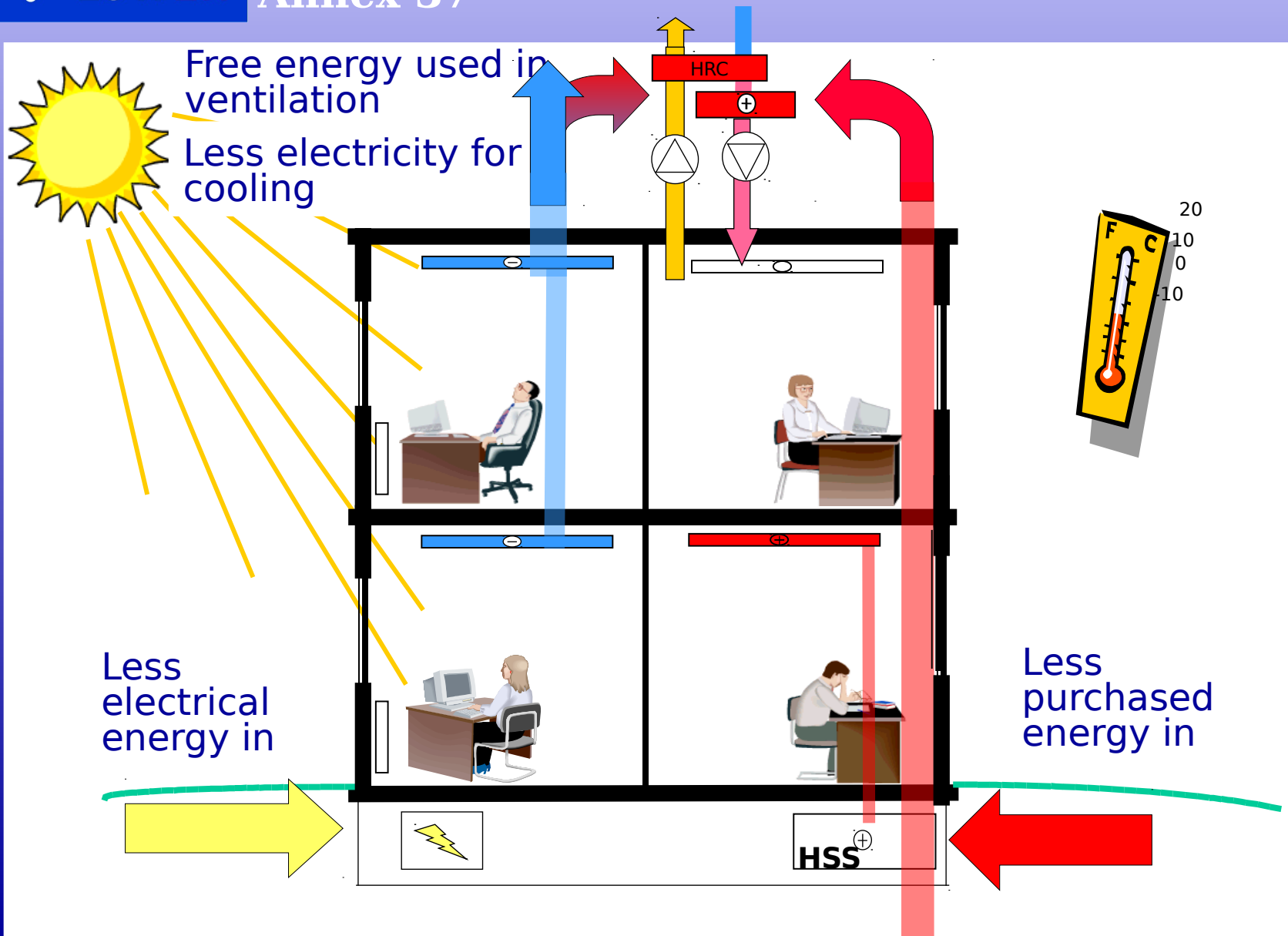
Sensus system



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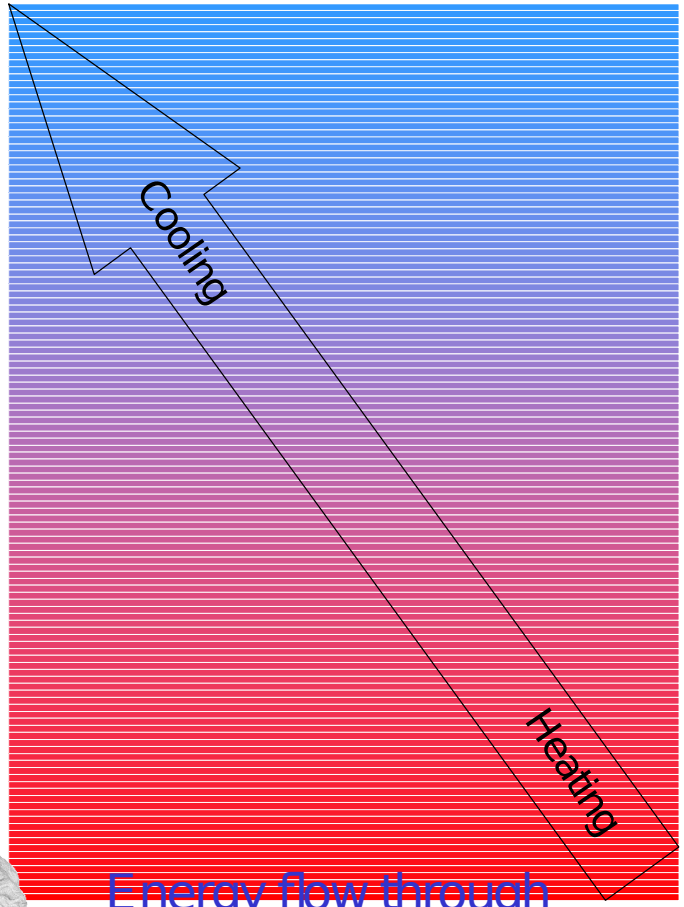
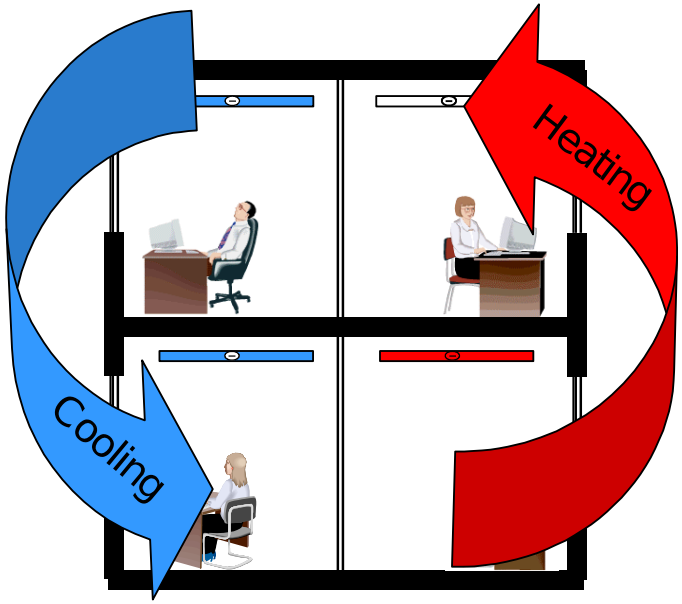
Traditional



Energy flow through the building

Sensus®



Energy is circulated

ARE Sensus®

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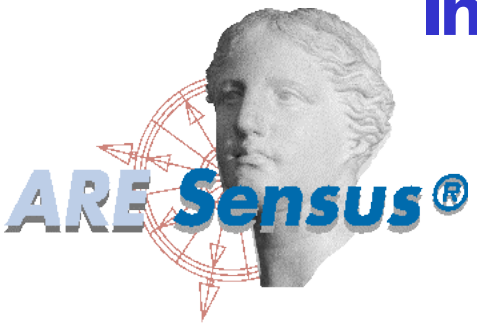
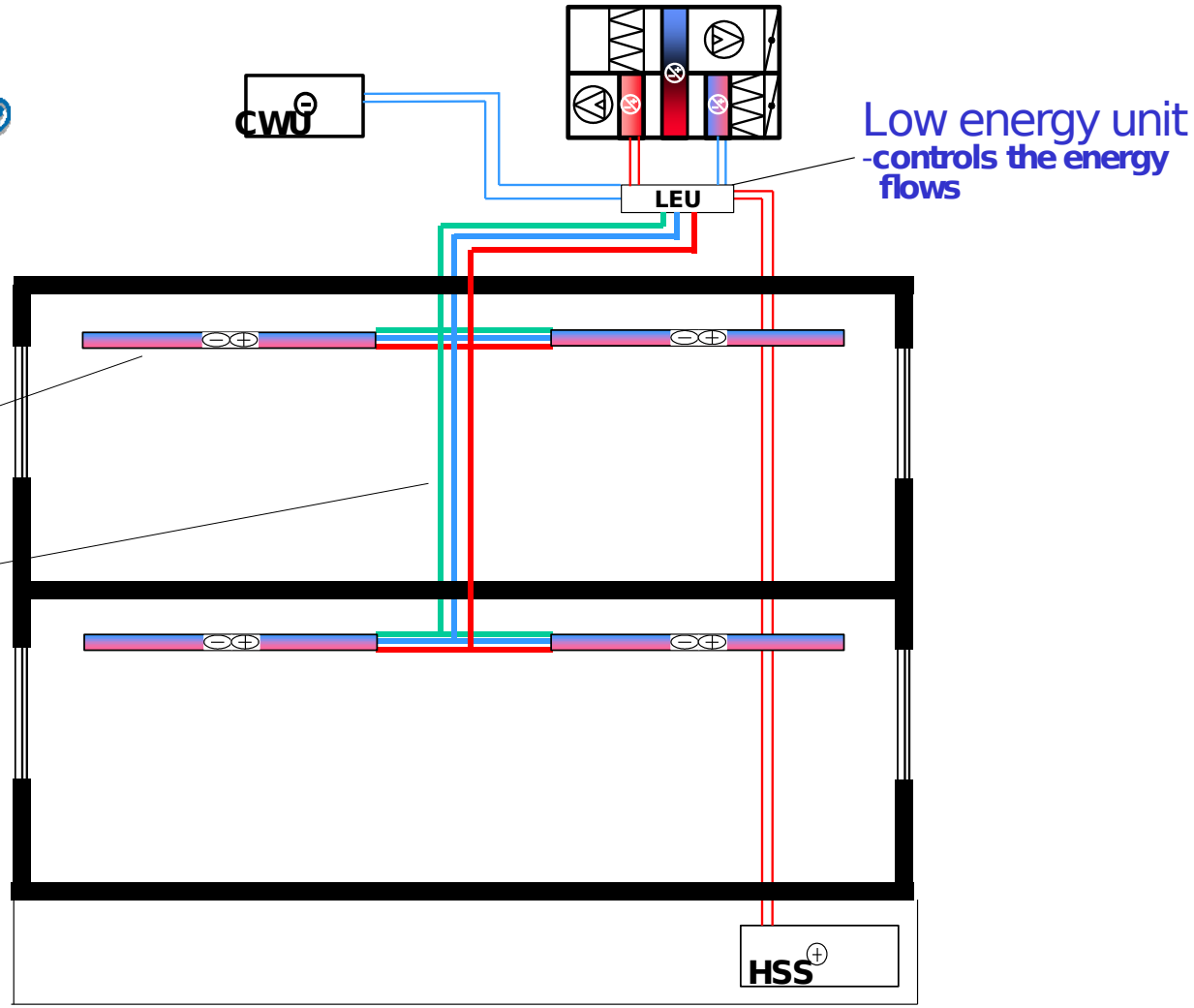
Integrated *Sensus*® Solution





Low energy unit
-controls the energy flows

Combined heating and cooling
- panels

3-pipe-system
-heating supply
-cooling supply
-combined return

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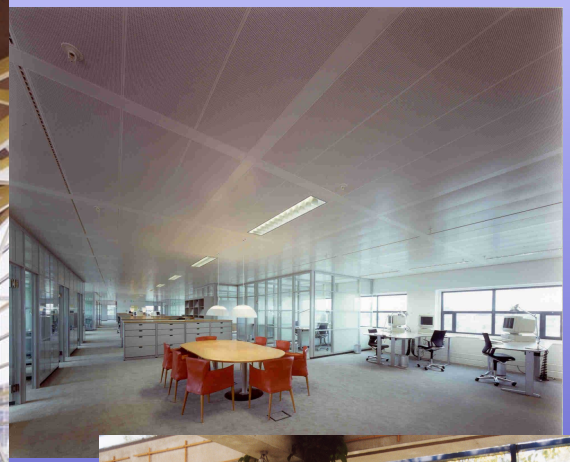

Case examples

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Case examples

- Information of 30 real estate cases:
  - project description (general data of the b
  - description of installations
  - installation schemes
  - experiences (measurements)
  - experiences (users)
  - literature references

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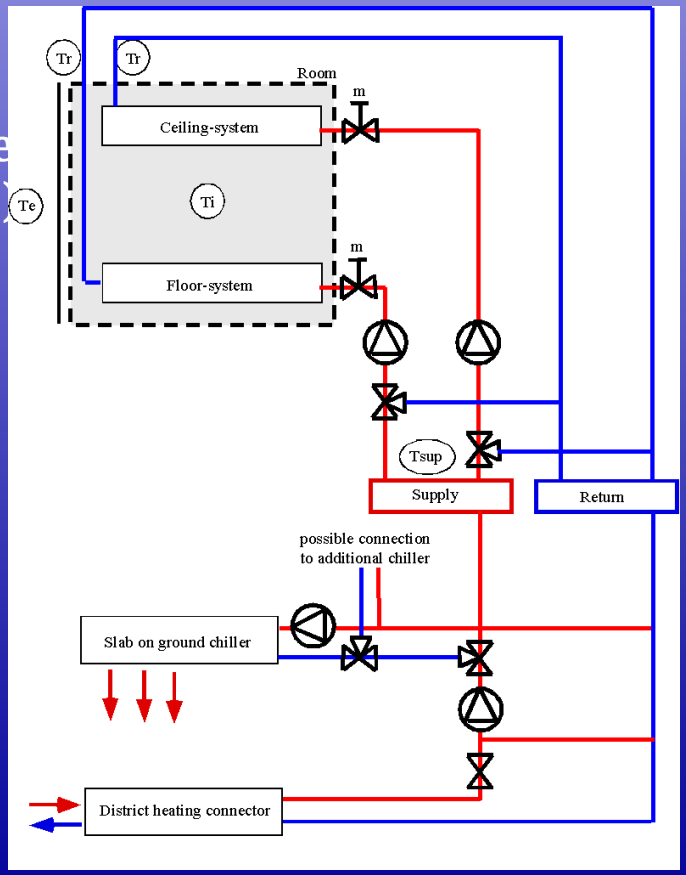
Demonstration proje
Centre for Sustainable Building

- **Location: Kassel, Germany**
- **Building type: Commercial (office exhibition hall and research hall)**
- **Floor area: 1000 m²**
- **Emission system: Floor heating/cooling**
- **Heat source: District heating**
- **Cold source: Ground cooling**



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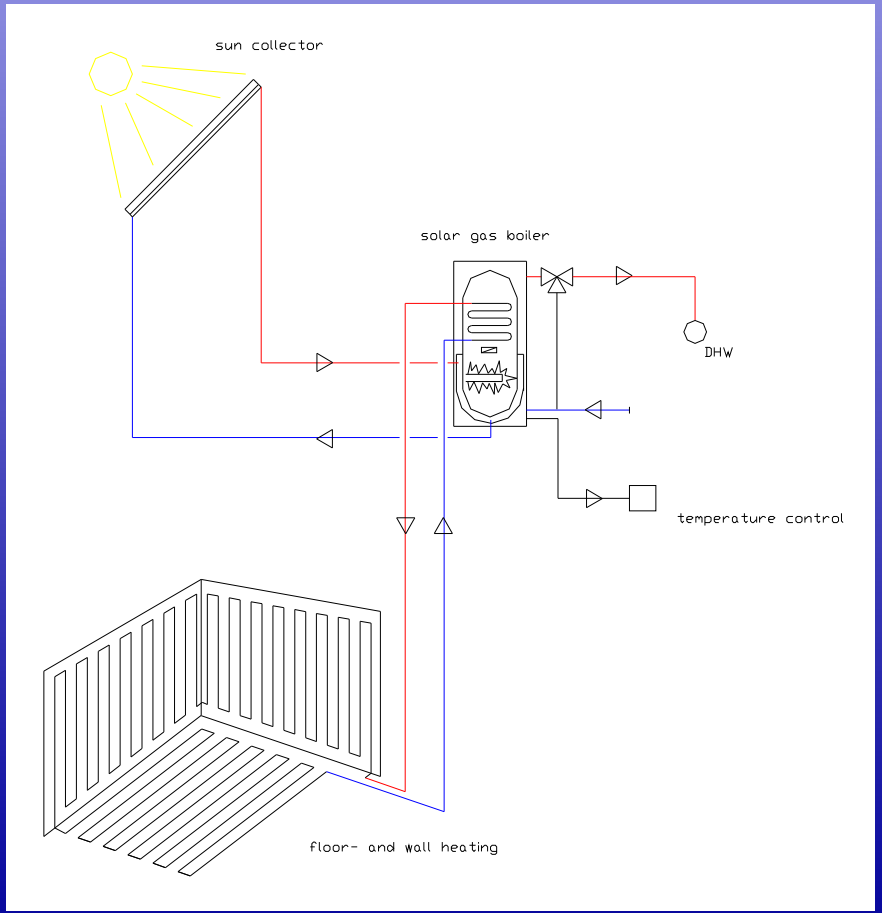
Case example: Carisven

- **Location: Heerlen, the Netherlands**
- **Building type: Residential (54 semi-detached houses)**
- **Floor area: about 134 m² each**
- **Emission system: Wall heating**
- **Heat source: Solar collectors and gas boiler**



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St. Martin church - Slovenia

- Emission: Wall-"Temperisation"
- Conservation of art work (frescoes)
- Improved microclimate, increased thermal comfort, lower energy use
- Oil boiler (to be replaced in future)

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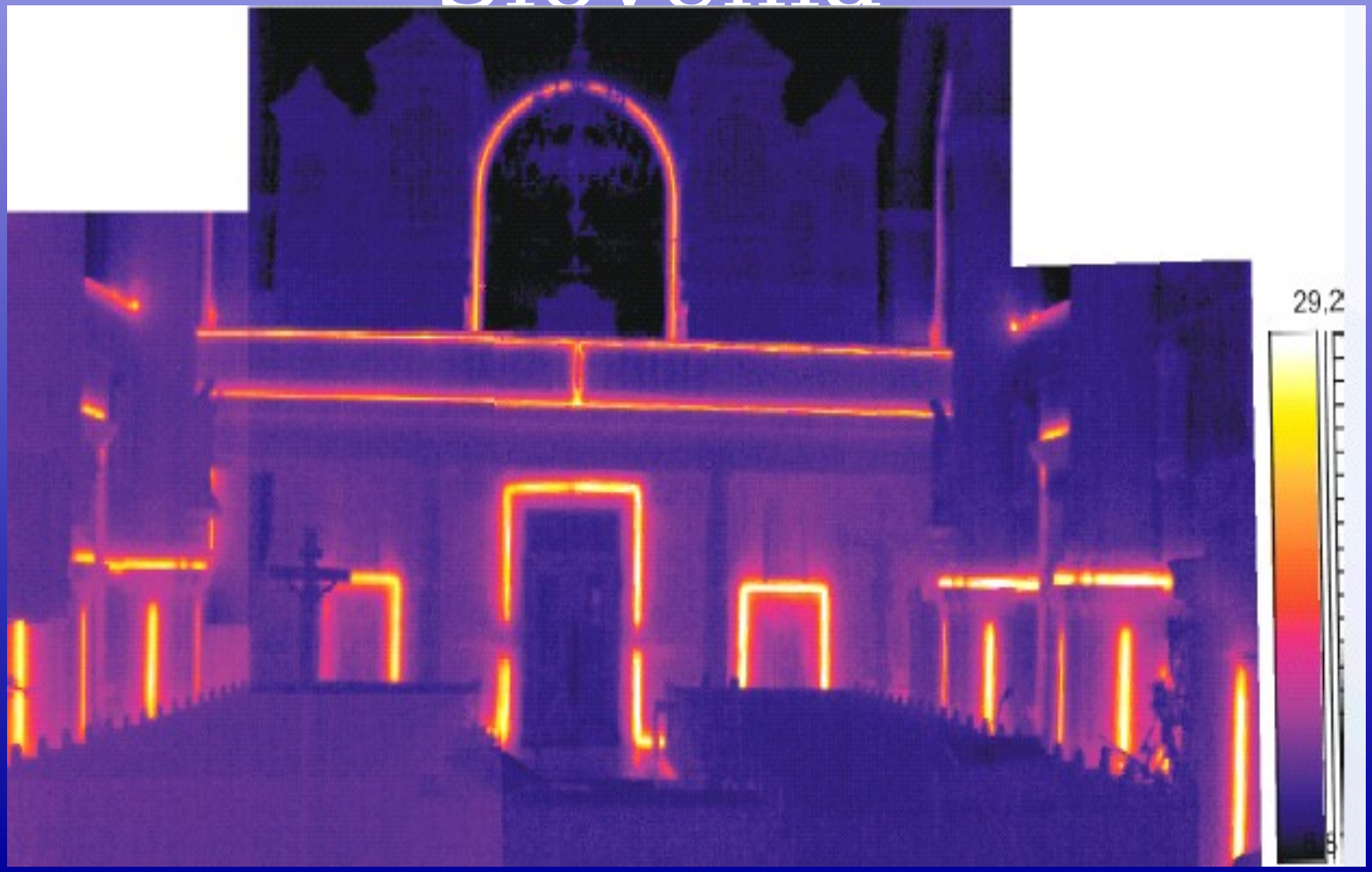
St. Martin church - Slovenia



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Conclusions…

- Exergy defines the quality of energy and is an important concept for designing and assessing different heating and cooling systems
- Low exergy systems are heating or cooling systems that allow the use of low valued energy as the energy source
- Low exergy systems provide heating or cooling energy at a temperature level close to room air temperature conditions

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…conclusions

- There are currently many low exergy technologies available
- The application of low exergy systems provides many additional benefits besides energy supply benefits such as: improved thermal comfort, improved indoor air quality and improved energy efficiency

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Thank you for
exergetic attention!

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